

# Revision of the Architectonicidae (Gastropoda: Allogastropoda) from the Miocene Chipola Formation, Oak Grove Sand, and Shoal River Formation of northern Florida, with descriptions of four new species

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## ABSTRACT

A revision of the Architectonicidae from the Miocene Chipola Formation, Oak Grove Sand, and Shoal River Formation of northern Florida is presented, along with descriptions of four new species. Two new species are assigned to the genus *Heliacus*, one to the genus *Architectonica* and a fourth to the genus *Granosolarium*.

*Additional key words:* *Architectonica*, *Heliacus*, *Granosolarium*, Tertiary, Neogene, fossil mollusks.

## INTRODUCTION

Of the estimated 1100 species of mollusks believed to be represented in northern Florida's Miocene Chipola Formation and Oak Grove Sand deposits only about 640 have been described (Vokes, 1989; 1997). Currently, between 120 and 130 undescribed species of mollusks from the Chipola Formation, Oak Grove Sand, and Shoal River Formation have been discovered by the author in the Invertebrate Paleontology collections at the Florida Museum of Natural History or in private collections. Included among those species that remain to be described are a broad range of specimens representing many different classes and families. This paper is intended to examine four of these new species in the family Architectonicidae.

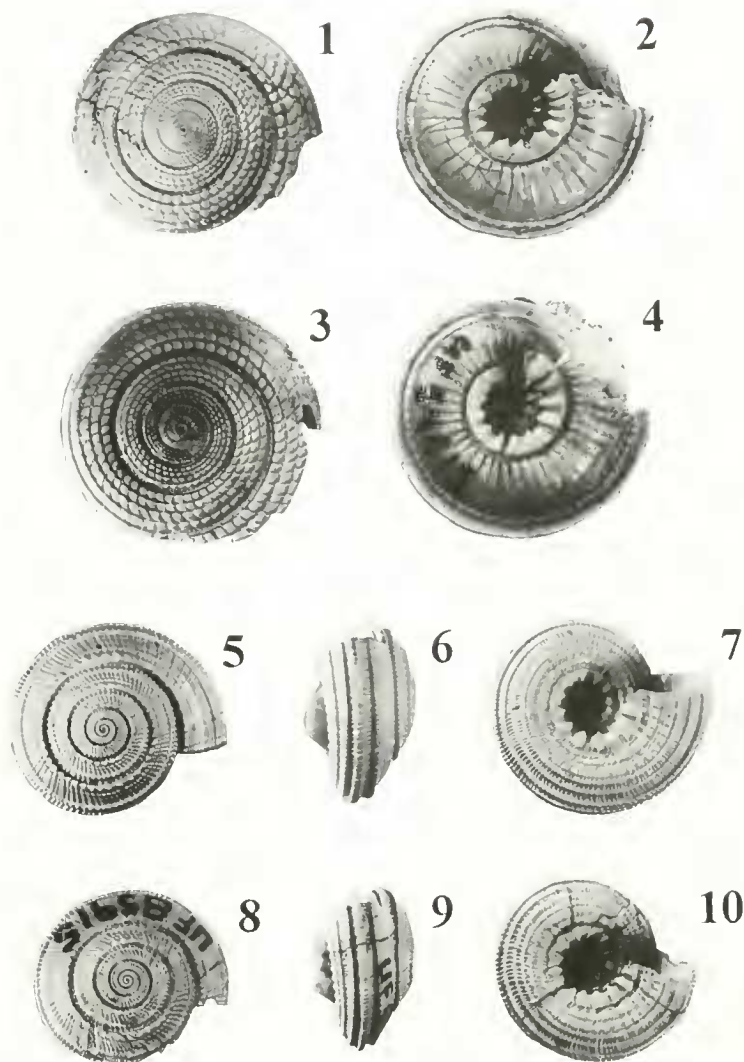
Bieler (1993) recognized about 140 living species of Architectonicidae. Approximately one third of these extant species are found in the Atlantic and the remainder in the Pacific and Indian oceans (Merrill, 1970). Numerous other species have been reported from fossil deposits (Gardner, 1947; Ladd, 1982; Maury, 1917; Olsson, 1922; Olsson, 1932; Robertson, 1973; Woodring, 1959). Representatives of this family usually have flattened, low-spired shells with heterostrophic protoconchs. Bieler (1993) reported that shells like those of architectonicids have been found in fossil deposits dating back to the Triassic. Among extant groups, Bieler (1993) noted that *Pseudomalaxis* and *Heliacus* appeared first in the

Cretaceous while *Architectonica* and other forms appeared in the Eocene. To date, including new forms reported in this paper, a total of eight species of the family are recorded in the Miocene Chipola Formation, Oak Grove Sand, and Shoal River Formation.

Gardner (1947) listed six members of the Architectonicidae from the Alum Bluff Group. Three were morphologically similar to *Architectonica nobilis* Röding, 1798. These include *Architectonica chipolana* (Dall, 1892) from the Chipola River and Tenmile Creek in Calhoun County, Florida, an unnamed subspecies of *Architectonica quadriseriata* (Sowerby, 1850) from the Oak Grove Sand in Florida and Georgia, and *Architectonica quadriseriata waltonensis* Gardner, 1936, from the Shoal River Formation in Walton County, Florida. Of the three remaining taxa, two belong to the genus *Architectonica*. They are *Architectonica alvcar* Gardner, 1936, from the Oak Grove Sand and *Architectonica verecunda* Gardner, 1936, from the Shoal River Formation. The third species belongs to the subfamily Heliacinae and was tentatively identified by Gardner (1947), from two "very young" specimens, as *Architectonica bisulcata* (d'Orbigny, 1842).

In this paper we look at four new members of the family Architectonicidae from the Chipola Formation. One is an uncommon species belonging to the genus *Architectonica* that has been collected from only two localities along Tenmile Creek. Two of the remaining species belong to the genus *Heliacus*. Of these, one is fairly common and is well represented in Chipola deposits. This species is most similar to the "very young" specimens of *A. bisulcata* reported by Gardner (1947). The second species of *Heliacus* is extremely rare and is known only from the holotype. The last representative belongs to the genus *Granosolarium*. It is also very rare and is represented by two specimens collected from one locality along Tenmile Creek.

The author also examined seven specimens of the subspecies of *Architectonica quadriseriata* reported by Gardner (1947) from the Oak Grove Sand, in order to



**Figures 1–10.** New species of Miocene Architectonicidae. 1–4. *Architectonica gemmosa* new species. 1, 2. Holotype, UF 93992, maximum height 11.8 mm, maximum width 23.5 mm. 3, 4. Paratype A, UF 54615, maximum height 9.2 mm, maximum width 15.1 mm. 5–10. *Heliacus (Torinista) calhounensis* new species. 5, 6, 7. Holotype, UF 93991, maximum height 5.0 mm, maximum width 15.0 mm. 8, 9, 10. Paratype A, UF 55915, maximum height 7.2 mm, maximum width 13.7 mm.

determine its taxonomic status. Six of these specimens are the material originally studied by Gardner (deposited at the National Museum of Natural History), while one is from the private collection of Greta and Andy Murray, Bradenton, Florida.

#### SYSTEMATICS

Superfamily Architectonicoidea Gray, 1850  
 Family Architectonicidae Gray, 1850  
 Genus *Architectonica* Röding, 1795

*Architectonica* Röding, 1795: 78. Type species: *Trochus perspectivus* Linnaeus, 1758, by subsequent designation of Gray, 1847.

#### *Architectonica gemmosa* new species (Figures 1–4)

**Description:** Shell size moderate, low-spired, cone-shaped. Protoconch smooth, maximum diameter 0.94–1.03 mm, with 1.5 whorls. Early half protoconch whorl depressed. Anal keel present. Teleoconch whorls 7, slightly convex, separated by deep, narrow suture. Each teleoconch whorl with 4 prominently sculptured, beaded spiral cords of equal size. Base of sutural groove formed by cord running along peripheral margin of body whorl. Umbilicus moderately wide, outlined by wide, denticulate spiral surrounded by deep, spiral groove. Straight, axial grooves radiate out from spiral groove and cross over wide, fairly smooth band, which, in some specimens, bears faint spiral threads. Two prominent.

raised spiral cords, separated by spiral groove, present at periphery of basal whorl. Innermost cord with well-developed, beaded sculpture. Outermost cord with less distinct sculpturing. In most instances, axial grooves radiating from spiral groove do not join beaded spiral cord on periphery. Shape of aperture unknown as it is badly damaged on all specimens examined.

**Holotype:** UF 93992, height 11.8 mm, width 23.5 mm.

**Paratypes:** Paratype A: UF 84615, height 9.2 mm, width 15.1 mm, from type locality; UF 93993–94000, 8 paratypes, Chipola Formation, north bank of Tennile Creek at powerline crossing about 1 mile west-northwest of mouth of creek at "Bailey's Ferry" (SE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida (Tulane University locality TU 830).

**Type locality:** Chipola Formation, Tennile Creek, about 1.25 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida (Tulane University locality TU 951).

**Distribution:** A decade of collecting *Architectonica* from numerous Chipola Formation sites and the examination of hundreds of specimens of *Architectonica* at the Florida Museum of Natural History indicates that *A. gemmosa* is an uncommon species that is exclusively associated with the ancient reef environment that existed along Tennile Creek in Calhoun County, Florida.

**Etymology:** Alludes to the species rarity and beautiful sculpture.

**Discussion:** A number of investigators have noted that living architectonicids have a long-lived veliger stage resulting in a broad geographical range for the adults (Bieker, 1993; Merrill, 1970; Scheltema, 1979). By comparing modern and fossil forms of Atlantic Architectonicidae, Scheltema (1979) was able to demonstrate that the veliger stage of Miocene members of this family also underwent extensive migrations. Hence, in order to make sure the newly discovered Chipola species had not already been described from other Miocene and Pliocene deposits worldwide, specimens were compared with those reported in the literature from a wide range of locations including Europe, the Mediterranean, West Africa, Caribbean, South and Central America, Pacific Ocean, as well as other locations in North America.

*Architectonica gemmosa* bears some similarities to *Architectonica alvear* Gardner, 1936, from the Oak Grove Sand, but *A. alvear* does not have well developed scale-like spiral cords on its dorsal surface and the rugose spiral cord that surrounds the umbilical carina in *A. alvear* is absent in *A. gemmosa*. The only other fossil species that bears any resemblance to *A. gemmosa* is *Architectonica nobilis karsteni* Rutsch, 1934, which was described from Miocene deposits in Venezuela (Rutsch, 1934), central Chile (Erassinetti and Covacevich, 1981) and southwestern Ecuador (Marks, 1951). Woodring (1959) also recorded this latter species from the Pliocene

Chagres Sandstone of Panama. However, *A. nobilis karsteni* does not have well developed scale-like spiral cords on its dorsal surface, its umbilical margin is less denticulate, and both peripheral cords on the ventral surface are smooth.

A cursory examination of the "*Architectonica quadriseriata* ssp." of Gardner (1947) from the Oak Grove Sand and Georgia revealed that it represents *Architectonica chipolana* (Dall, 1892) and should no longer be considered an undescribed subspecies of *Architectonica quadriseriata*.

Genus *Helicac* d'Orbigny, 1842

*Helicac* d'Orbigny, 1842: 65; introduced as "division" of *Solarium* [= *Architectonica*]. Type species: *Solarium herberti* Deshayes, 1830 [= *Helicac cylindricus* (Gmelin, 1791)], by monotypy, under the incorrect secondary spelling "herberti".

Subgenus *Torinista* Iredale, 1936

*Torinista* Iredale, 1936: 327. Type species: *Torinista popularedale*, 1936 = *Solarium implexum* Mighels, 1845, by original designation.

*Helicac* (*Torinista*) *calhounensis* new species  
(Figures 5–10)

**Description:** Shell small, depressed, with flattened apex. Protoconch smooth, sunken, maximum diameter 0.53 mm, with about 1.5 whorls. Anal keel present. Teleoconch whorls 5.5, separated by deep suture. Single row of well-developed, raised spiral cords runs along whorls just above and below suture. Two less distinct spiral cords lie between raised ones. Spiral cords crossed by strong radial ribs that give them beaded appearance. Five prominent, elevated, spiral cords extend from outer edge of last whorl to region halfway across base of shell. First 3 cords keel-like with second one being largest. Remaining 2 cords less distinct. Three prominently sculptured cords, two outermost beaded, innermost strongly denticulate, surround wide umbilicus. All raised spiral cords along side and base intersected by well-developed axial ribs. Aperture circular; outer lip crenulate.

**Holotype:** UF 93991, maximum height 8.0 mm, maximum width 15.0 mm.

**Paratypes:** Paratype A: UF 85915, maximum height 7.2 mm, maximum width 13.7 mm, Chipola Formation, Tennile Creek, about 1.25 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida (Tulane University locality TU 998); paratype lot UF 95074, 2 shells, Chipola Formation, Tennile Creek, about 1.25 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida (Tulane University locality TU 951); paratype lot UF 91794, 3 shells, Chipola Formation, east bank of Chipola River, about 1,000 feet above Fournile Creek (SW 1/4 Sec. 29, T1N, R9W), Calhoun County, Florida (Tulane University Lo-



cality TU 555); paratype lot UF 84566, 6 shells, Chipola Formation, Tenmile Creek, at powerline crossing about one mile west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida (Tulane University Locality TU 830); paratype lot UF 95075, 1 shell, Chipola Formation, Tenmile Creek, about 1 1/4 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida (Tulane University Locality TU 951); paratype lot UF 101100, 1 shell, Chipola Formation, Tenmile Creek, about 1.25 miles west of Chipola River (SE 1/4 Sec. 12 T1N, R10W), Calhoun County, Florida (Tulane University Locality TU 998).

**Type locality:** Chipola Formation, Tenmile Creek, about 1.25 miles west of Chipola River (SE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida (Tulane University locality TU 951).

**Distribution:** *Heliacus calhouensis* is a fairly common species that is widely distributed throughout fossil deposits found along Tenmile Creek, Farley Creek, and the Chipola River. Thus far there are no reports of it being collected from Oak Grove Sand.

**Etymology:** Named after Calhoun County, Florida.

**Discussion:** As a small member of the family Architectonicidae, *Heliacus* has a more reticulate and stronger sculpture than those individuals belonging to the genus *Architectonica* (Keen, 1971). Most *Heliacus* are 20 mm or less in size and extant individuals of this genera are identified by their distinctive spiral operculum which is a horny, pagoda-like structure with a fringed edge (Keen, 1971). Since the opercula are not preserved as fossils, other characteristics are used to differentiate fossil species. These features include the type sculpturing on the dorsal and ventral surfaces of the teleoconch whorls, the presence or absence of an anal keel, the widths of the protoconch and umbilicus, and the type of sculpturing surrounding the umbilicus.

Currently, Bieler (1993) has identified six subgenera that belong to the genus *Heliacus*. Based upon external morphological features, the two new species of *Heliacus* described in this paper have been assigned to the subgenus *Torinista*. According to Bieler (1993), this subgeneric group possesses disk-shaped teleoconch whorls with approximately five noded, spiral ribs. On the side of the body whorl, they also have strong lower peripheral and infraperipheral ribs surrounding one or two additional strong ribs.

*Heliacus calhouensis* was misidentified as *Architectonica* (*Pseudotorinia*) *bisulcata* d'Orbigny, 1853 by Gardner (1947), as she only had access to two very young specimens. An examination of several juvenile *H. calhouensis* by this investigator (two to three millimeters in diameter) revealed that the young do bear a slight resemblance to the latter species. However, the juveniles of *H. calhouensis* possess more heavily beaded spiral cords around the umbilicus and have fewer and less pronounced beaded spiral threads on the dorsal surface.

A number of species of *Heliacus* which appear to be-

long to the subgenus *Torinista* have been reported from different fossil deposits (Gardner, 1948; Jung, 1969; Ladd, 1982; Mansfield, 1930; Maury, 1917; Olsson, 1964; Petuch, 1994; Pilsbry, 1922; Woodring, 1959). *Heliacus calhouensis* is most similar to *Solarium stone-manac* Maury, 1917 from the Miocene Gatun Formation of Panama (Woodring, 1959) and the Pliocene deposits of the Cercado Formation in the Dominican Republic (Maury, 1917). However, it differs from this species by the presence of keel-like spiral cords along its periphery, faint spiral cords on the dorsal surface, and weaker radial growth lines.

Among extant species *H. calhouensis* is closely related to *H. planispira* (Pilsbry and Lowe, 1932), but is not flat-topped, has a more well developed suture between the dorsal whorls, and a wider, more denticulate cord surrounding the umbilicus.

*Heliacus* (*Torinista*) *compactus* new species  
(Figures 11-13)

**Description:** Small, depressed, cone-shaped shell with angular periphery. Protoconch smooth, maximum diameter 0.64 mm, with 1.3 whorls. First 0.5 protoconch whorl sunken. Anal keel present. Five teleoconch whorls, first 2.5 whorls flattened, the remainder angled at 45° toward periphery. Suture distinct, narrow. Five axial rows of irregular-shaped beaded cords present on surface of whorls. These include two medium-size beaded cords adjacent to the suture followed by a single, narrow axial row of beads, a wide trapezoid scale-like cord, and a double row of narrow beads at the periphery. An angled periphery is formed by 2 peripheral ribs. The area between the peripheral ribs sculptured with trapezoid, scale-like beads. Five prominently beaded cords surround deep umbilicus, the innermost one strongly denticulate. Aperture oval.

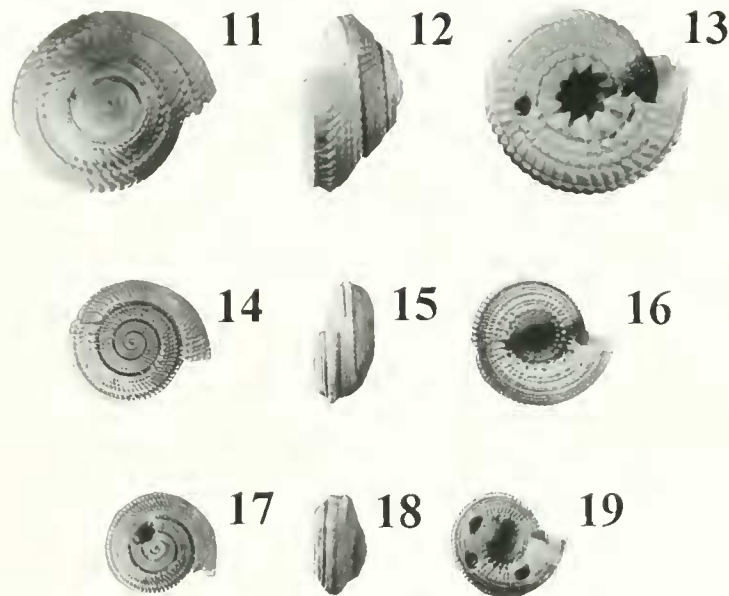
**Holotype:** UF 93987, maximum height 6.8 mm, maximum width 11.3 mm.

**Type locality:** Chipola Formation, Tenmile Creek about 1.75 miles west of Chipola River (NE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida (Tulane University locality TU 546; = USGS 2212, "one mile west of Bailey's Ferry").

**Distribution:** *H. compactus* is a very rare species that is only known from the type locality.

**Etymology:** Alludes to tightly spiraled sculpture on the body whorls.

**Discussion:** *Heliacus compactus* is a unique member of this genus and does not bear a strong resemblance to any other species from the Chipola Formation, Oak Grove Sand, and Shoal River Formation. From the fossil record *Architectonica* (*Pseudotorinia*) *guppyi* Jung, 1969, and *Architectonica* (*Architectonica*) *fuscicava* McNeil, 1984 are the only species which exhibit any similarities to *H. compactus*. The former species is known



**Figures 11–19.** New species of Miocene Architectonicidae. **11–13.** *Heliacus (Torinista) compactus* new species, Holotype, UF 93957; maximum height 6.8 mm, maximum width 11.3 mm. **14–19.** *Granosolarium floridanum* new species. **14, 15, 16.** Holotype, UF 96324; maximum height 2.0 mm, maximum width 6.3 mm. **17, 18, 19.** Paratype A, UF 96325; maximum height 1.8 mm, maximum width 4.5 mm.

from several small specimens that were found in the Pliocene deposits of Matura Bay in Trinidad (Jung, 1969). Both *H. compactus* and *A. guppyi* are low spired shells with with submerged protoconch that possess five beaded axial cords on the teleoconch whorls and have an angulate periphery. However, *H. compactus* is much larger, has a much more flattened apex, and the sculpturing on its dorsal and ventral surfaces differ considerably from *A. guppyi*. *Architectonica fuscicava* comes from Oligocene Mint Spring Formation and the Byram Formation of Mississippi (McNeil and Dockery, 1984) and is probably the ancestor to the Miocene species. *Heliacus compactus* is about the same size and possesses the same general shape as *A. fuscicava*, but the spiral beaded sculpturing on both the dorsal and ventral surface of *H. compactus* is much larger than the beaded sculpturing on *A. fuscicava*.

#### Genus *Granosolarium* Sacco, 1892

*Granosolarium* Sacco, 1892: 59. Type species: *Solarium millegianum* Lamarck, 1822, by original designation.

#### *Granosolarium floridanum* new species (figures 14–19)

**Description:** Shell small, trapezoid-shaped with beaded spiral sculpture and sharp, beaded peripheral keel. Protoconch smooth, depressed, maximum diameter 0.54–0.65 mm, distinctly heterostrophic, with 2 whorls. Anal keel present. Teleoconch 3.5 whorls, deep suture between each whorl. Opposing sides of each teleoconch whorl with prominent beaded cord adjacent to suture.

Between the prominent beaded spiral cords on each whorl, are three, less distinct, tile-like cords. Umbilicus very wide. Lower inner peripheral margin of body whorl extends down into umbilicus, which bears two parallel, strongly beaded carinae, that spiral toward the inner apex of shell (into umbilicus). Remainder of ventral surface with six beaded spiral cords of irregular size. Aperture oval.

**Holotype:** UF 96324, maximum height 2.0 mm, maximum width 6.3 mm.

**Other type material:** Paratype A, UF 96325, maximum height 1.8 mm, maximum width 4.5 mm, from type locality.

**Type locality:** Chipola Formation, north bank of Ten-mile Creek at powerline crossing about 1 mile west-northwest of mouth of creek at "Bailey's Ferry" (SE 1/4 Sec. 12, T1N, R10W), Calhoun County, Florida (Tulane University locality TU 830).

**Distribution:** This appears to be a very rare species that has thus far been collected only from the ancient reef environment of the type locality.

**Etymology:** Named after the state of Florida.

**Discussion:** *Granosolarium floridanum* readily stands out from the rest of the Architectonicidae found in the Chipola Formation. In general, it has the overall body form of the genus *Architectonica* but differs from this group by its broad umbilicus and prominent peripheral keel. Bieler (1993) assigned members of the Architectonicidae with these characteristics to the genus *Granosolarium*.

*Granosolarium floridanum* bears some similarity to *Architectonica* (*Pseudotorinia*) *euprepes* Woodring, 1928, from the Pliocene of Jamaica. Both are about the same size, but *G. floridanum* is more dorso-ventrally compressed, the sutures on the dorsal surface are more distinct, and it possesses fewer beaded spiral cords around the umbilicus. *Granosolarium floridanum* is somewhat similar to *Granosolarium asperum* (Hinds, 1844) an extant form which is listed by Bieler (1993) from a number of diverse locations including Australia, New Zealand, Indonesia, and West Africa.

*Granosolarium asperum* has also been reported from the middle Miocene fossil deposits of Australia (Garrard, 1961) and from the Pleistocene deposits of New Hebrides (Ladd, 1982). However, *G. floridanum* differs from *G. asperum* in that it possesses tile-like sculpturing on its dorsal surface and paired, strongly beaded, carinae around the outer margin of the umbilicus.

Four species of *Granosolarium* have been described from Eocene deposits in the New World, but they are all larger and have finer dorsal and ventral sculptural features than those in *G. floridanum*. Two were collected from the Moodys Branch Formation in Louisiana and described by Palmer (1947). They are *Architectonica* (*Granosolarium*) *ornata jacksonia* Palmer, 1947, and *Architectonica* (*Granosolarium*) *meckana subsplendida* Palmer, 1947. *Architectonica aldrichi* (Dall, 1892) was collected from the Lower Claiborne of Mississippi and *Architectonica claborata* was obtained from the lower Claiborne and Gosport Sand of Alabama (Palmer, 1937).

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#### LITERATURE CITED

- Bieler, R. 1985. Die Gattungen der Architectonicidae (Gastropoda: Allogastropoda). Teil 3: *Architectonica*, *Nipteraxis*, *Heliacus*, *Eosolarium*. Archiv für Molluskenkunde 116:89-117.
- Bieler, R. 1993. Architectonicidae of the Indo-Pacific (Mollusca, Gastropoda). Gustav Fischer Verlag, Stuttgart, 376 p., 3 pls.
- Frassinetti, D. and V. Covacevich. 1981. Architectonicidae en la Formacion Navidad, Mioceno, Chile Central Parte II. *Architectonica* (*Architectonica*) *nobilis karsteni* Rutsch.
1934. Boletín del Museo Nacional de Historia Natural 35: 147-154, 4 figs., 1 tab.
- Gardner, J. 1947. The molluscan fauna of the Alum Bluff Group of Florida. Pt. 5: Ctenobranchia (remainder), Aspidobranchia, and Scaphopoda. United States Geological Survey, Professional Paper 142-H:493-656, pls. 52-62.
- Gardner, J. 1948. Mollusca from the Miocene and lower Pliocene of Virginia and North Carolina. Pt 2. Scaphopoda and Gastropoda. United States Geological Survey, Professional Paper 199-B:179-279, pls. 24-35.
- Garrard, T. A. 1961. Mollusca collected by M.V. "Challenge" off the east coast of Australia. Journal of the Malacological Society of Australia 1(5):2-37, pls. 1-2.
- Gray, J. E. 1847. A list of the genera of Recent Mollusca, their synonyma and types. Proceedings of the Zoological Society of London 15:129-219.
- Jung, P. 1969. Miocene and Pliocene mollusks from Trinidad. Bulletins of American Paleontology 55(247):259-657, pls. 13-60.
- Keen, A. M. 1971. Sea shells of tropical West America. 2nd ed. Stanford University Press, Stanford CA, xiv + 1064p.
- Ladd, H. S. 1982. Cenozoic fossil mollusks from western Pacific islands: Gastropods (Eulimidae and Volutidae through Terebridae). United States Geological Survey, Professional Paper 1171:iv + 100 pp., pls. 1-41.
- MacNeil, F. S. and D. T. Dockery III. 1954. Lower Oligocene Gastropoda, Scaphopoda, and Cephalopoda of the Vicksburg Group in Mississippi. Mississippi Department of Natural Resources, Bureau of Geology Bulletin 124:1-415, pls. 1-72.
- Mansfield, W. C. 1930. Miocene gastropods and scaphopods of the Choctawhatchee Formation of Florida. Florida Geological Survey Bulletin 3:1-185, pls. 1-21.
- Marks, J. G. 1951. Miocene stratigraphy and paleontology of southwestern Ecuador. Bulletins of American Paleontology 33 (139):1-162, pls. 1-9.
- Maury, C. J. 1917. Santo Domingo type sections and fossils. Part 1: Mollusca. Bulletins of American Paleontology 5 (29):1-251, pls. 1-39.
- Merrill, A. S. 1970. The family Architectonicidae (Gastropoda: Mollusca) in the western eastern Atlantic. Unpubl. Ph.D. thesis, University of Delaware: 338 pp., 42 pls. (University Microfilms International, Inc., Ann Arbor, No. 71-6444.)
- Olsson, A. A. 1922. The Miocene of northern Costa Rica with notes on its general stratigraphic relations. Pt. 1. Bulletins of American Paleontology 9 (39):1-167, pls. 1-15.
- Olsson, A. A. 1932. Contributions to the Tertiary paleontology of northern Peru. Pt. 5. The Peruvian Miocene. Bulletins of American Paleontology 19 (65):1-264, pls. 1-24.
- Olsson, A. A. 1964. Neogene mollusks from northwestern Ecuador. Paleontological Research Institution: 256 p., 35 pls.
- Palmer, K. V. W. 1937. The Claibornian Scaphopoda, Gastropoda and Dibranchiate Cephalopoda of the southern United States. Bulletins of American Paleontology 7 (32), pt. 1, 1-545, pt. 2, pp. 549-730 pls. 1-90.
- Palmer, K. V. W. 1947. Univalves and index: p. 207-563, pl. 26-56, 62-65. In: Harris, G. D. and K. V. W. Palmer (eds.) The Mollusca of the Jackson Eocene of the Mississippi Embayment (Sabine River to the Alabama River). Bulletins of American Paleontology 30(117):1-533, pls. 1-65.
- Petuch, E. J. 1994. Atlas of Florida Fossil Shells (Pliocene and Pleistocene marine gastropods). Spectrum Press, Evanston, 394 pp., 100 pls., 20 text-figs.
- Pilsbry, H. A. 1922. Revision of W. W. Gabb's Tertiary Mollusca

- of Santo Domingo. *Proceedings of the Academy of Natural Sciences of Philadelphia* 73:305–435, pls. 16–47.
- Pilsbry, H. A. and H. N. Lowe. 1932. West Mexican and Central American mollusks collected by the H.N. Lowe, 1929–31. *Proceedings of the Academy of Natural Sciences of Philadelphia* 84: 33–144, pls. 1–17.
- Robertson, R. 1973. On the fossil history and intrageneric relationships of *Philippia* (Gastropoda: Architectonicidae). *Proceedings of the Academy of Natural Sciences of Philadelphia* 125:37–46.
- Röding, P. F. 1798. *Museum Boltenianum sive catalogus cimeliorum e tribus regnis naturae. . . pars secunda. . .* J. C. Trapp, Hamburg, viii+199 pp.
- Rutseh, R. 1934. Die Gastropoden aus dem Neogen der Punta Gavilan in Nord-Venezuela. *Abhandlungen der Schweizerischen Paläontologischen Gesellschaft* 54–55: 1–169, 20 figs., pls. 1–20.
- Sacco, F. 1892. I molluschi dei terreni terziarii del Piemonte e della Liguria, 12 (Pyramidellidae [fine], ringiculidae, Solaridae e Scalaridae [aggiunte]). C. Clausen, Torino, 86 pp., 2 pls.
- Scheltens, R. F. 1979. Dispersal of pelagic larvae and the zoogeography of Tertiary marine benthic gastropods. In Gray, J. and A. J. Boucot (eds.) *Historical Biogeography, Plate Tectonics and the Changing Environment*. Oregon State University Press, Corvallis, pp. 391–397, 6 figs.
- Vokes, E. H. 1989. An overview of the Chipola Formation, northwestern Florida. *Tulane Studies in Geology and Paleontology* 22:13–24.
- Vokes, E. H. 1997. Notes on the fauna of the Chipola Formation—XLIII. Additions to the molluscan fauna since 1947. *Tulane Studies in Geology and Paleontology* 3:211–216.
- Woodring, W.P. 1928. Contributions to the geology and paleontology of the West Indies. Miocene mollusks from Bowden, Jamaica. Part II: Gastropods and discussion of results. *Carnegie Institute of Washington Publication* 355: i–viii, 1–564, pls. 1–40.
- Woodring, W. P. 1959. Geology and paleontology of Canal Zone and adjoining parts of Panama. Description of Tertiary mollusks (Gastropods: Vermetidae to Thaididae). United States Geological Survey, Professional Paper 306-B:1–239 pp., pls. 24–35.